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XVII.

THE MÉCANIQUE CÉLESTE OF LAPLACE, AND ITS TRANSLATION WITH A COMMENTARY BY BOWDITCH.

BY JOSEPH LOVERING.

Presented June 8, 1889.

LAPLACE was born in Beaumont-en-Auge on March 28, 1749. The early years of his life are hidden in the obscurity of his humble origin. It is only known that he was the son of a small farmer. He first gained distinction in a theological controversy. After attending some of the classes in a military school in Beaumont, he taught mathematics there. At the age of eighteen, he approached the great D'Alembert with the hope of finding some career in Paris, and was rebuffed. Afterwards, Laplace sent to him a letter on the *Principles of Mechanics*. D'Alembert wrote back: "You see that I make little enough of the matter of recommendations. You have no need of them. You have done better: to know. This is enough for me: my support is your due." Thus he mounted at once to the position of Mathematical Professor in the Military School at Paris. Before entering the Paris Academy, at the age of twenty-four, he began his career of investigation by which he won the title of the Newton of France, having made a capital discovery relating to the mean distances of the planets from the sun. Laplace was also an investigator in physics and chemistry, working with Lavoisier and Berthollet. Only fifteen days before his last sickness, he communicated to the Memoirs of the Academy a paper on the oscillations of the earth's atmosphere, which was printed in the same volume which contained Poisson's funeral oration.

Of his three great works, the five volumes of the *Mécanique Céleste* were published between 1799 and 1827; the *Exposition du Système du Monde* in 1796; and the *Théorie analytique des Probabilités* in 1812. Arago reported, in 1842, that not a copy of the last work was in the libraries of Paris, although three editions had been published, and that the two other works were almost out of print, so that he feared that it would be necessary to order from America Bowditch's translation. In this emergency Madame de Laplace, always devoted to the reputation and memory of her dead husband, was negotiating for the sale of a small farm in order to provide the means of republishing his works, when the government of Louis Philippe took the matter in hand and appropriated forty thousand francs for a new edition. This appeared, in seven quarto volumes, between 1843 and 1847. At a later period, when this edition was nearly exhausted, General Laplace, the distinguished son of the mathematician, and his granddaughter, the Marquise de Colbert, expended seventy thousand francs on a third edition, which appeared between 1878 and 1886.

Laplace was the friend of young mathematicians and physicists, such as Arago, Poisson, and Biot, who were called "the adopted children of his thought." At an early age, while still a pupil in the Polytechnic School, Arago was attached to the Paris Observatory as secretary. He has given in his Autobiography the following interesting sketch of Laplace. He says: "I entered this establishment, then, on the nomination of Poisson, my friend, and through the intervention of Laplace. The latter loaded me with civilities. I was happy and proud when I dined in the Rue de Tournon with the great geometer. My mind and my heart were much disposed to admire all, to respect all, that was associated with one who had discovered the cause of the secular acceleration of the moon, had found in the movement of this satellite the means of calculating the ellipticity of the earth, had traced to the laws of gravitation the long inequality of Jupiter and Saturn, etc., etc. But what was my disenchantment when, one day, I heard Madame de Laplace approach her husband, and say to him, 'Will you intrust to me the key of the sugar?'"

Another anecdote told by Arago is not so complimentary to Laplace. Delambre, the Perpetual Secretary of the Academy of Paris, died on the 19th of August, 1822. A committee was appointed to present candidates for the succession. The choice lay between Fourier and Biot. The election was always by secret ballot, — Arago frankly saying that no one wished to incur the disaffection of a successful candidate against whom he had voted. Laplace wrote the *same* name upon two ballots, put them in his hat, and shook them up. He took one out and tore it, and put the other in the urn, pretending not to know for whom he had voted, though an indiscreet neighbor did. No calculus of probabilities, Arago says, was needed for this problem.

Twenty-three years after the death of Laplace, Biot confided to the Academy of Paris these interesting reminiscences of him. "Every one," he says, "will understand how valuable to a young man were these familiar and intimate interviews with a genius so powerful and so comprehensive. But what he might not imagine were the sentiments of affectionate and paternal delicacy which attended them, unless he himself had been the object of them. Shortly after I was permitted to approach him, I had the good fortune to take a step, which seemed to me new and unexpected, in a field of mathematics hitherto scarcely invaded. In 1766, Euler had treated a peculiar class of geometrical questions by an indirect method in a paper entitled *De insigni promotione methodi tangentium inversæ*.* Subsequently, he attacked a more difficult problem of the same kind, to which he repeatedly returned with different solutions, but always indirect. The singularity of the problem originated in the nature of the curve, the geometrical characters being of different orders, — some belonging to points infinitely near, others to distant points separated by finite differences. I succeeded in rendering a complete statement of the problem in analytical language, applying to each part appropriate symbols. The realization of this idea surpassed my expectations.†

"After I had found the key to a solution of the problem, I spoke to Laplace about it. He listened with attention and with some surprise, and then said, 'It seems all very well; come to-morrow morning and bring your memoir; I shall be glad to see it.' After hearing it, discussing it, and suggesting certain omissions, he told me to present it to the Academy the next day, and, after the session, come and dine with him. 'Now,' said he, 'let us lunch.'"

Biot communicated his paper to the Academy in the presence of Monge, Lagrange, Laplace, and of Bonaparte who had just returned from Egypt. Bonaparte pretended to recognize the diagrams, though no one had ever seen them before except Laplace. "I had more fear of Lagrange," said Biot, "than of Bonaparte, with all his military glory."

After Biot had read his paper, and received the congratulations of the Academicians, he accompanied Laplace home. As soon as they had entered the house, Laplace took Biot into his study, unlocked a closet, took out a copy-book, yellow with age, and showed him all the problems resolved by the method which Biot had supposed to be original with himself. When Biot read his paper to Laplace he was cautioned against certain inferences at the end which Laplace thought too remote. "Go not," he said, "beyond the results which you have actually obtained. You will probably meet difficulties more serious than you suppose: the actual state of analysis cannot furnish you the means of surmounting them." And Biot struck out his hazardous inferences. It now appeared that Laplace had been arrested by the same obstacle which he had signalized to Biot. Hoping to surmount it later, he had said nothing about it to any one, not even to Biot, when he came to bring him his own work as if it were a novelty. Biot does homage to the abnegation of Laplace in allowing him to make his communication without the consciousness of having been anticipated. Laplace would allow no allusion to be made to the transaction when Biot's paper was printed. No mention of it appears in the records of the Academy. Not until after fifty years did Biot feel at liberty to mention it. "This discovery, the first I had made, was everything for me. It was little for him who had made so many. Would he always have been so just? Would he be so generous to a rival? I have no occasion to examine that here. He was all this for me, and for many others who began their career in this way."

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* Nov. Comment. Petrop., x.

† Considerations sur les équations aux différences mêlées; Mém. Savants Etrangères, i. 296–328.

Biot has described the country-seat of Laplace in Arcueil, adjoining that of the eminent chemist, Berthollet. "It was acquired by him in 1806, two years after the Emperor, Bonaparte, had promoted him to the first dignities of the Senate. He bought it without having seen it, on the report of Madame Laplace, being contented to know that it was adjacent to that of his friend Berthollet. A simple garden wall separated them. Berthollet had cut an opening in it and placed a gate there before Laplace arrived. Then he came to receive him with ceremony at the boundary of their domains, bringing the keys which would give them free access to each other. It was in this delicious retreat that Laplace spent every day, every moment, of liberty that his business left to him, — not to give himself to indolent repose, but to continue, with unwearied passion, his great labors on mathematical physics and the system of the world, emerging from these meditations only to converse with his friend on physics and chemistry. Here he also welcomed a retinue of zealous young men, whom he condescended afterwards to call his colleagues, and who always were proud of this association. Around him, in a more elevated sphere, were seen continually Berthollet, Lagrange, Cuvier, etc., to whom he introduced his young protégés. Here Laplace died, on March 5, 1827.

His last words were, 'Ce que nous connaissons est peu de chose; ce que nous ignorons est immense.' This sanctuary of sciences has been preserved, with a religious respect, by Madame Laplace, to whom it belongs to-day (1850). The house, the gardens where he walked, are as they were then. The study in which he composed so many noble works remains untouched, with the same furniture and books that served him in the state in which he left them. He alone is wanting, to the profound regret of those who knew him and will never see his equal."

If we turn from this attractive picture of the domestic and scientific life of Laplace to his public career, the contrast is not pleasant. Living in the most disturbed period of France, he managed to keep himself always in the ascendency. After the *coup d'état* of Napoleon, in 1799, his republican ardor was replaced by devotion to the First Consul. But his incapacity as Minister of the Interior led to his removal in six weeks. It was charged against him that he brought into his administration the principles of the infinitesimals. As a consolation, he was given a place in the Senate, of which he was made Chancellor in 1803. He was also Grand Officer of the Legion of Honor. On the erection of the Imperial throne, in 1804, he was made a Count. In 1814, he gave his voice for the Provisional Government, the deposition of Napoleon, and the restoration of the Bourbons. Louis XVIII. rewarded him by a seat in the Chamber of Peers, and in 1817 by a Marquisate.

The first edition of the *Exposition du Système du Monde* was inscribed to the Council of Five Hundred. The third volume of the *Mécanique Céleste*, published in 1802, was a tribute to the Pacificator of Europe. In the edition of the *Théorie analytique des Probabilités*, published after the restoration, the dedication to the Emperor in an earlier edition was suppressed.

Bonaparte recognized the splendor which the great intellect of Laplace shed upon his administration. On October 19, 1801, having received a volume of the *Mécanique Céleste*, he wrote to the author: "The first six months at my disposal will be employed on your beautiful work." On November 26, 1802, after reading some chapters of a new volume dedicated to himself, he refers to "the new occasion for regret that the force of circumstances had directed him to a career which led him away from that of science. At least, he added, I desire ardently that future generations, reading the *Mécanique Céleste*, should not forget the esteem and friendship I have borne to the author." On June 6, 1805, the General having become Emperor, he wrote from Milan: "The *Mécanique Céleste* seems to me called to give a new splendor to the age in which we live." On August 12, 1812, he wrote from Witepsk: "There was a time when I should have read with interest your *Traité du Calcul des Probabilités.* To-day, I must limit myself to testifying to you the satisfaction I experience every time I see you communicate new works which perfect and extend the first of the sciences and contribute to the glory of the nation. The advancement and perfectionation of mathematics are bound to the prosperity of the state."

Arago did not imitate the political subserviency of Laplace, much as he admired his genius. In early life he went to Spain with Biot, to complete a geodesic operation. This expedition, though full of adventure and danger, had a successful issue, by giving a more precise value to the magnitude of the earth. On his return he was made a member of the Paris Academy when scarcely twenty-three years old. His scientific career was brilliant, and in 1830 he replaced Fourier as Perpetual Secretary. In 1848 he espoused the cause of the second republic, with Louis Bonaparte as President. After the second *coup d'état,* he refused to take the oath of allegiance to the new government, required of all officials. Nevertheless, he was allowed to retain the post of astronomer in the *Bureau de Longitude,* the new Emperor "making an exception in favor of a savant whose works had thrown lustre on France, and whose life his government would regret to embitter." As Minister of the Marine, Arago had originated and carried an act for abolishing slavery in the French colonies. Being urged to delay the change and make it gradually, he declared, "I will not postpone till to-morrow an act which sets free the oppressed."

Poisson was of humble origin, but rose to be Peer of France. He befriended Arago, who was five years younger, and who describes him in his youth as of delicate complexion, slight figure, and childish manner. At the age of eighteen, he submitted to his teacher, Lagrange, some amelioration in the method of demonstrating the binomial theorem, which his teacher read publicly in his lectures, and said he should adopt. Laplace wished to know a geometer who had made such a beginning. Poisson was one of the earliest and the most powerful in applying Fourier's definite integrals and periodic series to physical problems. He extended the conclusions of Lagrange and Laplace on the stability of the solar system, adding millions of years to its probable duration. As there was no vacancy in the French Academy in his proper section, he was placed in that of Physics. Afterwards much of his work was upon physical problems, such as electricity, magnetism, and capillarity. By common consent, he stood at the head of European analysts, after the death of Laplace, whom he succeeded as geometer in the *Bureau de Longitude.*

The publication of Dr. Bowditch's great work, a translation of four volumes of Laplace's *Mécanique Céleste*, with an ample commentary, was heralded by an article which he wrote for the North American Review in 1820. After describing the works of Olbers and Gauss in mathematical astronomy, the three principal publications of Laplace, and especially his discovery of the great equation in the motions of Jupiter and Saturn, with its long period of 917 years, and the neglect by men of science in Great Britain of the vigorous science upon the Continent, he thus expresses his admiration of Laplace: "These discoveries, together with a multitude of improvements in analysis and in every branch of mathematical knowledge, place this immortal man far above any of his contemporaries in the walks of science."* Fourier had called Laplace's works the *Almagest* of the eighteenth century.

Professor John Playfair, having alluded to the absence of diagrams and geometrical figures in the writings of the great mathematicians of France, says: "If we come to works of still greater difficulty, such as the *Mécanique Céleste*, we will venture to say that the number of those in this island who can read that work with any tolerable facility is small indeed. If we reckon two or three in London and the military schools in its vicinity, the same number at each of the two English Universities, and perhaps four in Scotland, we shall not hardly exceed a dozen: and yet we are fully persuaded that our reckoning is beyond the truth."†

On the appearance of the first volume of Bowditch's translation, a writer in the London Quarterly Review expresses his admiration in these words: "The idea of undertaking a translation of the whole *Mécanique Céleste*, accompanied throughout with a copious running commentary, is one which savors, at first sight, of *gigantesque*, and is certainly one which, from what we have had hitherto reason to conceive of the popularity and diffusion of mathematical knowledge on the opposite shores of the Atlantic, we should never have expected to have found originated, or at least carried into execution, in that quarter. Meanwhile, the part actually completed (which contains the first two books of Laplace's work) is, with few and slight exceptions, just what we could have wished to see, — an exact and careful translation into very good English, — exceedingly well printed, and accompanied with notes appended to each page which leave no step in the text, of moment, unsupplied, and hardly any material difficulty of conception or reasoning unelucidated." Referring to the continuance of the work, the writer adds: "Should this unfortunately not be the case, we shall deeply lament that the liberal offer of the American Academy of Arts and Sciences to print the whole at their expense, was not accepted." *

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* North American Review, 1820, vol. x. pp. 260–272.

† Edinburgh Review, 1808, vol. xi. p. 281.

In 1838, after three volumes of the translation and commentary had been published, a writer in the London Athenæum expresses himself in these words: "Dr. Bowditch rose, like Franklin, from humble life, and had much to struggle with, and did struggle manfully, and did succeed. He was, in other words, an illustrious instance of a *self-educated man*. . . . No matter what a man's facilities may be, without this (the possession and use of the appropriating and incorporating power) he can never be educated, any more than he can be healthy without sound bodily organs.

"The lack of facilities is not, however, to be spoken of lightly, though it must not be confounded, nor yet compared, with the lack of the power that uses them: nor must it be supposed that such a thing as an absolute lack of facilities can exist. Nature herself has provided facilities, food for education, materials for self-making men to rise up, in times and places when and where no other facilities may be had. She opens the great school-room of creation for them. She gives them homes, society, the world at large. Above all, she gives them eyes to see, and ears to hear, and an all-availing and available spirit within them: the intellectual, immortal instinct, the thirst for knowledge, and the faculty of finding it, in earth, and air, and sea. No loads of appliances can surfeit such a mind on the one hand; no lack of them can starve it on the other.

"Let us not be supposed, then, to use the words as abusing them, when we call Dr. Bowditch an illustrious instance of a self-educated man. He was, in other words, as *we* understand it, an educated man: his intellect informed and trained, his character seasoned and consummated, and this under those circumstances of extraordinary self-dependence, which, it is well known, are so admirably suited to bring out and give their finest play to minds of a high order, on the very same principle that they prove fatal to weaker ones. . . .

"Dr. Bowditch's great scientific work — the one on which his

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* Quarterly Review, vol. xlvii., 1832, pp. 558, 559.

European reputation rests and will rest — was a translation of the *Mécanique Céleste* of Laplace, accompanied with an extensive explanatory commentary, making a work, which existed one may say in mere abstraction before, as accessible to all public and popular purposes as its essential nature would permit." *

Dr. Bowditch's work was not that of a mere translator and commentator. The subject was brought down to the date of publication, and was illustrated by the labors of geometers and astronomers who had succeeded Laplace. Such mathematicians as Lacroix, Legendre, Bessel, and Puissant recognized the great value of these additions. Mr. Babbage, in a letter to Dr. Bowditch, under date of August 5, 1832, wrote: "It is a proud circumstance for America that she has preceded her parent country in such an undertaking; and we in England must be content that our language is made the vehicle of the sublimest portion of human knowledge, and be grateful to you for rendering it more accessible." Letters of similar import were received by Dr. Bowditch from Airy, Francis Baily, Herschel, the Bishop of Cloyne (Dr. Brinkley), and Cacciatore.

The Council of the Royal Astronomical Society of London,† in noticing Dr. Bowditch's commentary and notes upon Laplace, expresses its appreciation in these terms: "An expert mathematician would find most of them (*the notes*) useless; but to the student who has sufficient knowledge to understand, without the habit of previous investigation which the reading of Laplace always requires, the work of Dr. Bowditch is invaluable. We see in it, not the performance of a practised analyst, but the record of the steps by which the translator became one; and a person more familiar with the most modern form of analysis than he appears to have been at the time when he wrote would probably have filled his commentary with difficulties of the same order as those of his author. This, however, was not done; and the work, as it stands, is most unquestionably fitted to bring the *Mécanique Céleste* within the grasp of a number of students exceeding five times, at least, that of those who could master Laplace by themselves.

"The name of Dr. Bowditch must be long remembered in the United States by the impulse which such a work as his commentary cannot fail to give to analysis in that country. The undertaking required sound knowledge, power of combining brevity and clearness, an accurate remembrance of the nature of a beginner's difficulties, and determined perseverance. The congratulations which this society would so cordially have offered to the performer of this strikingly useful task can now only be forwarded, with expressions of sympathy and condolence, to his surviving relatives and friends; with the hope that astronomy, theoretical and practical, will flourish in the country which has produced so remarkable a facilitation of the study of the former, and so sound an example of the union of both."

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* London Athenæum, 1838, pp. 451, 452.

† Memoirs, vol. xi. pp. 300, 301.

In a note to the memoir of Dr. Bowditch by his son, it is stated that in America two, and perhaps three persons, besides Dr. Bowditch, were able to read the original work critically; but a competent judge has doubted whether the whole of it had been so read even by one. It is also known, on the authority of his son, that Dr. Bowditch was gratified whenever he received assurances that his work had made Laplace accessible to young students, — more even than he was by the approbation of his peers.

Benjamin Peirce, who was born in Salem, Mass., in 1809, and died at Cambridge in 1880, and who was Professor of Mathematics or Astronomy for forty-seven years, enjoyed the most intimate social and scientific relations with Dr. Bowditch. How these relations originated we are told by the writer of his obituary notice prepared for the American Academy of Arts and Sciences.*

"In his early years he had the good fortune to come under the influence of Dr. Nathaniel Bowditch. It is said that their first acquaintance was made while Dr. Bowditch's son, Ingersoll, and young Peirce were schoolmates. Ingersoll showed his comrade a solution which his father had prepared of a problem that the boys had been at work upon. Some error, real or conceived, was pointed out in the work, which was reported by Ingersoll to his father. 'Bring me that boy who corrects my mathematics!' was the invitation to an acquaintance, the importance of which, in Professor Pierce's own estimation, is told in the dedication, more than thirty years later, of his *Analytic Mechanics:* 'To the cherished and revered memory of my Master in Science, Nathaniel Bowditch, the father of American Geometry.'

"Peirce entered Harvard College in 1825. As Dr. Bowditch was now in Boston, having removed from Salem in 1823, and was preparing the first volume of his translation of Laplace's *Mécanique Céleste* for the press, it followed almost as a matter of course that the college student was more influenced in his studies by him than by the college course. Dr. Bowditch's first volume was completed, and the second entered for copyright, in 1829, the year of Peirce's graduation; and the proof-sheets were regularly read by him." *

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* Proceedings, vol. xvi. pp. 443, 444.

That it should have been left to this country to open a way to English-speaking nations for the study of the transcendental mathematics of France and Germany may be explained by the following lamentation of the younger Herschel, printed as late as 1845.† After acknowledging the celerity with which everything valuable in British journals is republished, examined, and criticised in those on the Continent, he writes: —

"This ought to encourage our men of science. They have a larger audience, and a wider sympathy than they are, perhaps, aware of; and however disheartening the general diffusion of smatterings of a number of subjects, and the almost equally general indifference to profound knowledge in any, among their own countrymen, may be, they may rest assured that not a fact they may discover, nor a good experiment they may make, but is instantly repeated, verified, and commented upon in Germany, and we may add too in Italy. We wish the obligation were mutual. Here, whole branches of Continental discovery are unstudied, and indeed almost unknown even by name. It is in vain to conceal the melancholy truth. We are fast dropping behind. In mathematics we have long since drawn the rein, and given over a hopeless race. In chemistry the case is not much better."

At the present day Great Britain no longer lies under this severe reproach. In pure mathematics there have been Boole, Hamilton, Cayley, H. J. S. Smith, Clifford, and Sylvester; and in applied mathematics, Adams, Stokes, Sir William Thomson, Lord Rayleigh, Challis, and Powell. But the highest mathematical faculty will be always the prerogative of the few. Not many can say with Lagrange, "I found chemistry as easy as algebra!"

The contrast is not less striking in this country between the present condition of mathematical taste and acquirement and what they were at the time of Bowditch's translation. This change has been largely

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* In the memoir of Dr. Bowditch by his son it is said: "Whenever one hundred and twenty pages were printed, Dr. Bowditch had them bound in a pamphlet form, and sent them to Professor Peirce, who, in this manner, read the work for the first time. He returned the pages with the list of errata, which were then corrected with a pen or otherwise in every copy of the whole edition."

† On Sound. Encyclo. Metropolitana, vol. iv. p. 810.

due to the example and inspiration of Peirce. Though he was a poor teacher for indifferent students, he was the best for superior intellects. He simply led, and charmed them into following him as far and as fast as they could. While his text-books were an enigma to those who had little mathematical capacity, they fascinated minds of the highest order in this direction. Hence, in every class in college, a very few were found competent to read Bowditch's version of Laplace, and obtain glimpses of the meaning of Peirce's ideal algebras. Observatories, the United States Coast Survey, the Nautical Almanac, the Smithsonian Institution, and schools of science exist, partly as cause and partly as effect of this new development. Bowditch's Practical Navigator, first published in 1802, has carried his name, long ago, over every ocean and into every port in the civilized world, and his scientific reputation, as the earliest American expounder of the higher geometry, is slowly following after.

The four volumes of Dr. Bowditch's Translation and Commentary were published successively, in 1829, 1832, 1834, and 1839, at the sacrifice of one quarter of his whole property. The expense was largely increased by the voluminous commentary. This was really of the nature of an original work, and was rendered necessary by the frequent gaps which Laplace had left in his own publication. Mr. N. I. Bowditch says, in his biography of his father, that Dr. Bowditch himself was accustomed to remark, "Whenever I meet in Laplace with the words, *Thus it plainly appears*, I am sure that hours, and perhaps days, of hard study will alone enable me to discover *how* it plainly appears."

The attention of Mr. James B. Francis of Lowell was attracted by the following passage in a recent work of W. W. R. Ball of London: "The *Mécanique Céleste* is by no means easy reading. Biot, who assisted Laplace in revising it for the press, says that Laplace himself was frequently unable to recover the details in the chain of reasoning, and, if satisfied that the conclusions were correct, he was content to insert the constantly recurring formula, *Il est aisé à voir*." *

Mr. Ball refers to the *Journal des Savants*, February, 1850. Mr. Francis has found the volume in the Boston Public Library. The title of the paper, translated, is, "An anecdote relating to Laplace: read to the French Academy at its special session, on February 5, 1850, by Mr. J. B. Biot." I find that Biot reprinted the paper in 1858, in his *Mélanges Scientifiques et Littéraires*. As Mr. Francis has been at the pains of obtaining a translation of the paper by a lady, I shall adopt that with a few trifling changes.

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* A Short Account of the History of Mathematics. London, 1888, p. 387.

"When a man of order prepares to depart on a long journey, he arranges his affairs, and is careful to discharge all the debts he may have contracted. This is why I am going to tell you how, some fifty years ago, one of our scientists, the most distinguished, received and encouraged a young débutant who had come to show him his first attempts.

"This young débutant was myself, with your leave. Notice, to excuse the epithet, that this goes back to the month Brumaire of the year VIII. of the French republic, first edition.* Some months later, they did me the signal honor of electing me an associate of the National Institute; but at that date, and especially at the little earlier period when my story begins, I found myself completely unknown. I was then quite a small professor of mathematics in the Central School of Beauvais. Having recently left the Polytechnic School, I had much zeal and less science. At that time, little was demanded of young men but zeal. I was impassioned for geometry and many other things. Fortune rather than reason saved me from yielding to tastes too diverse. Bound from that time by the sweetest ties to the interior of the family which had adopted me, happy in the present and counting on the future, I only thought of following with delight the bent of my mind towards all kinds of scientific studies, and of doing for pleasure what the interest of my career would have prescribed to me as a duty. I had, above all, an unbounded ambition to penetrate into the high regions of mathematics, where men discover the laws of the universe. But these grand theories, still scattered in the collections of academies, were almost unapproachable, except to a small number of superior men who had co-operated in establishing them; and to launch into them without a guide over their footsteps, this would be an enterprise in which one would have every chance of wandering for a long time before rejoining them. I knew that Laplace had labored in unifying this magnificent *ensemble* of discoveries in the work which he has very justly called the *Mécanique Céleste.* The first volume was in press; the others would follow, at long intervals, agreeably to my desires. A step which might appear very hazardous opened to me a privileged entrance into this sanctuary of genius. I ventured to write directly to the illustrious author, and beg him to permit his publisher to send me the sheets of his book as they were printed. Laplace replied to me with no less ceremony than if I had been a real savant. However, as the end of the story, he refused my request; not wishing, he said, that his work should be presented to the public before it was completed, that it might be judged as a whole. This polite refusal was doubtless very obliging in its form ; but, at bottom, it badly suited my business. I was not willing to accept it without appeal. I immediately wrote again to Laplace to represent to him that he did me more honor than I merited, and than I desired. I am not, I said to him, of the public who judge, but of the public who study. I added, that, wishing to follow and make again all the calculations throughout, for my own instruction, I might, if he yielded to my request, discover and indicate the errors of press which may have slipped into them. My respectful persistence disarmed his reserve. He sent to me all the sheets already printed, adding thereto a charming letter; this time not at all ceremonious, but filled with the most lively and precious encouragements. I need not say with what ardor I devoured this treasure. I could well apply to myself the maxim, *Violenti rapiunt illud.*

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* Brumaire began in 1799 on October 23: Biot was then twenty-five years old.

"After this, every time I went to Paris, I carried my work of typographical revision, and presented it in person to M. Laplace. He received it always with kindness, examined it, discussed it; and that gave me an opportunity to submit to him the difficulties which too frequently baffled my weakness. His condescension to remove them was without bounds. But he himself could not always do it, without giving attention to them ; sometimes pretty long. That happened usually in places where, to save himself from the details of a too expanded exposition, he had employed the expeditious formula, *Il est aisé de voir.* The thing, in fact, had appeared at the moment very clear to his eyes. But it was not so always, even for him, some time afterwards. Then, if you asked him the explanation of it, he sought it patiently, by different ways, on his own account as well as yours ; and *there* was, without doubt, the most instructive of commentaries. Once I saw him pass almost an hour trying to seize again the chain of reasoning which he had concealed under this mysterious symbol, *Il est aisé de voir.* It must be said, for his acquittal, that if he had wished to be completely explicit, his work would have required eight or ten quarto volumes instead of five ; and perhaps he would not have lived long enough to finish it."

These minute details relating to the intellectual life of Laplace, so sacredly preserved by Biot, the eminent mathematician and physicist, were not published until twenty-three years after the death of Laplace, and twelve years after the death of Bowditch. They must be taken into account when the mathematical powers of the author of the *Mécanique Céleste* and of its translator and commentator are compared. There can be no doubt that a higher order of mind is demanded for originating a profound analysis, than for understanding it when it is once made. Dr. Bowditch said to one of his sons: "My order of talent is very different from that of Laplace. Laplace originates things which it would have been impossible for me to have originated. Laplace was of the Newton class; and there is the same difference between Laplace and myself as between Archimedes and Euclid." This confession, taken in connection with Bowditch's estimate of Euclid, erred on the side of excessive modesty. For he was able not only to detect and point out to Laplace accidental errors in his work, but to provide an original commentary upon it more voluminous than the work itself. If this required a great expenditure of time and thought, it was no easy matter for Laplace himself. It was, in fact, so hard, that Laplace was not willing to undertake it a second time, after the subject had passed out of his mind; and he left the abyss open, with no stronger bridge to cross it than the simple formula, *Il est aisé de voir.*

The circumstances under which Laplace and Bowditch did their work are in striking contrast. Laplace was a favored child of fortune. He was able to give his long life of seventy-eight years to his noble task, breathing an intensely intellectual atmosphere, and surrounded by men of science only a little less distinguished than himself. Bowditch's knowledge of affairs was as remarkable as his science. He was weighted all his life with heavy cares and trusts, and could spare only his hard-earned leisure for scientific work, dying at the age of sixty-five. His intellect worked on a solitary height, admired but not fully comprehended by those about him. For example, instruction, and inspiration, he did as much for science in America, and wherever the English language is read, as Laplace did for that of France. It would be unjust to his memory, and to his own great modesty, to make any other comparison.

No names more illustrious adorn the two original branches of membership in this Academy than those of Laplace and Bowditch. Laplace was elected a Foreign Honorary Member in 1822, when he had published only four volumes of the *Mécanique Céleste.* Bowditch became a Resident Fellow in 1799, fifteen years before he had begun his translation of Laplace's greatest work. He contributed twenty-three valuable papers to the Memoirs, chiefly on Astronomy and the Physics of the Globe. Having succeeded John Quincy Adams as President of the Academy in 1829, he died in office, in 1838. An elaborate eulogy was pronounced before the Academy, May 29, 1838, by Mr. John Pickering, the Corresponding Secretary.

After the death of Laplace, his widow recognized the value of Bowditch's labors, in extending the usefulness and enlarging the fame of her husband's greatest work, by presenting to his translator and commentator his marble bust. In the fourth volume of the last edition of Laplace's work, fifty-two corrections are specified as having been made by Dr. Bowditch.

Dr. Bowditch's strength held out until he had corrected the proof-sheet of the thousandth page of the fourth volume of his translation. That was the last page his eye was to rest on. Eighteen more pages remained. The incident has its parallel in the death of Copernicus. He had spent twenty-three years in writing his book *De Orbium Cœlestium Revolutionibus*, but delayed its publication for fear of a popular outcry against his scientific doctrines. The book had been printed at Nuremberg under the care of his disciple, Rheticus. A few hours before he died, a copy arrived which was placed in his hands. He touched it, and seemed to recognize it, and then relapsed into unconsciousness.

No less suggestive was the death-bed of Lagrange. Though of French extraction, he was born in Turin in 1736. His father lost his property in speculation, — an event which the son did not regret. "Had I been rich," he said, "I might never have known mathematics." At the age of twenty-six, Lagrange had reached the summit of fame, though at the sacrifice of his health. In 1766, he was brought to Berlin by Frederick the Great, "the greatest king in Europe wishing to have the greatest mathematician at his court." Afterwards, various other courts competed for him. In 1787, he selected Paris. He was patronized by Marie Antoinette, and lodged in the Louvre. In the Revolution, when other scientific men were victims, his name commanded respect. In reply to a petition in favor of Lavoisier it was said, "The republic has no need of savants." Bonaparte called Lagrange "La haute pyramide des sciences mathematiques," and loaded him with offices and distinction. The first edition of his *Mécanique Analytique* appeared in 1788. In 1811, he published the first volume of another edition. The second volume, which was on *Dynamics*, required more serious changes, and its preparation was too much for his failing strength. On April 8, he had a conversation with Monge and other friends, and looked forward to another early interview, when he would complete some autobiographical details. But what he intended to say was never spoken. He died two days afterwards, and was buried in the Pantheon.

Only one Fellow of this Academy is now living who was elected before the death of Dr. Bowditch; and there must be very few in its present membership who knew him or ever saw him. But his work and his reputation are their common inheritance. To keep alive his memory, and do justice to his gigantic undertaking, is the loving service of one who, in early life, was welcomed to the hospitality of his thoughts and his books.